Journal Bearing Upgrade to Solve Reliability Issues in an Accessory Gearbox.

John K. Whalen, PE
TCE/Turbo Components & Engineering

Lorenzo Aburto
Conoco Phillips Alaska

INTRODUCTION

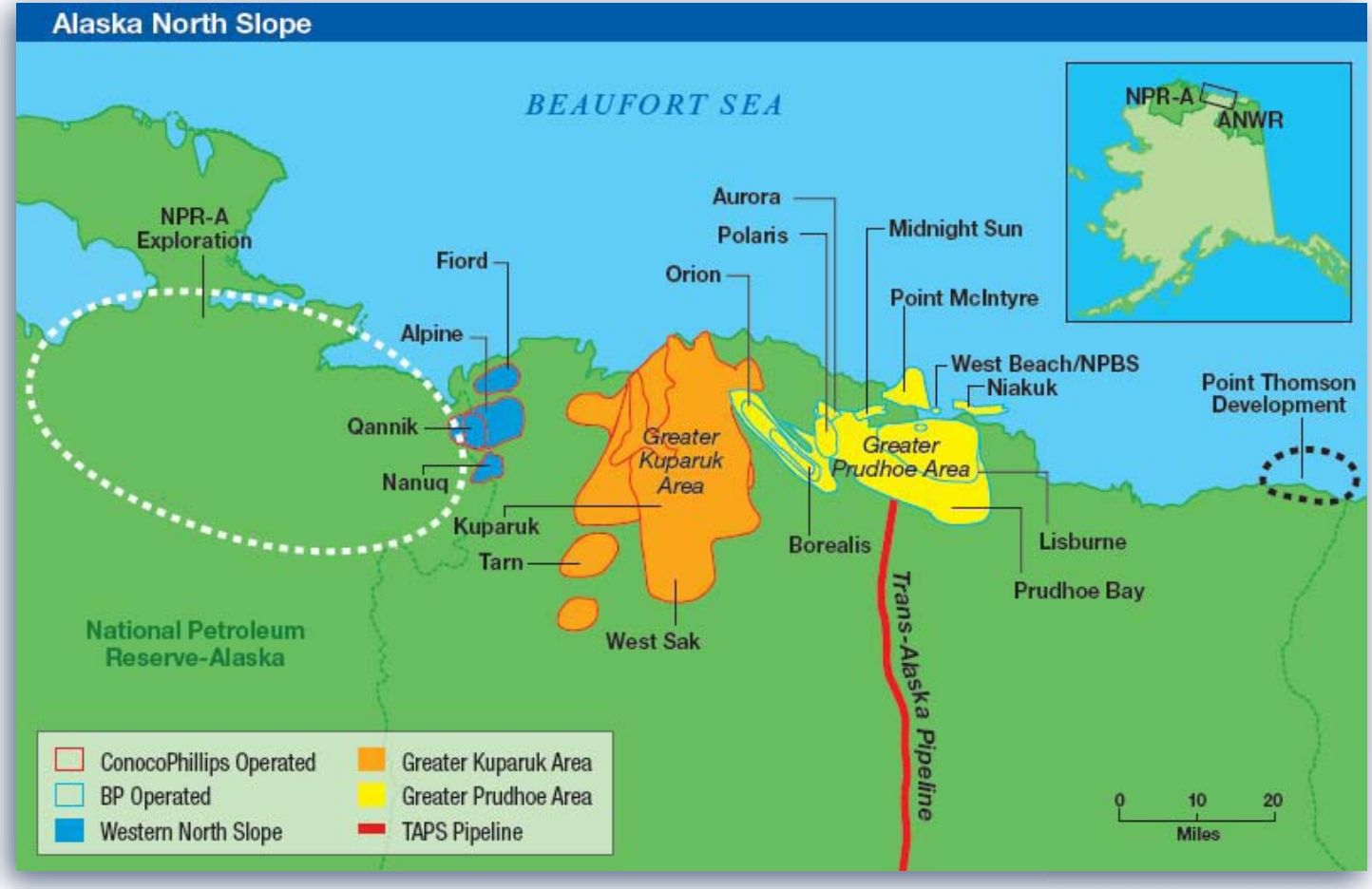
- Accessory gearbox on gas turbine - generator
- Gas turbine vital for operation of Alpine field on the north slope of Alaska
- Accessory gearbox journal bearings failed on several occasions – brought gas turbine down
- Failures attributed to varying load directions
- Redesigned to replace sleeve bearings with tilting pad journal bearings

ConocoPhillips Alpine Field

- Operator: ConocoPhillips
- Located 40 miles west of Kuparuk.
- Alpine is the largest onshore oil field discovered in North America in the past 20 years.
- It began producing in late 2000.
- Its 2008 net crude oil production was 44MBD.

Data from ConocoPhillips website

ConocoPhillips Alpine Field

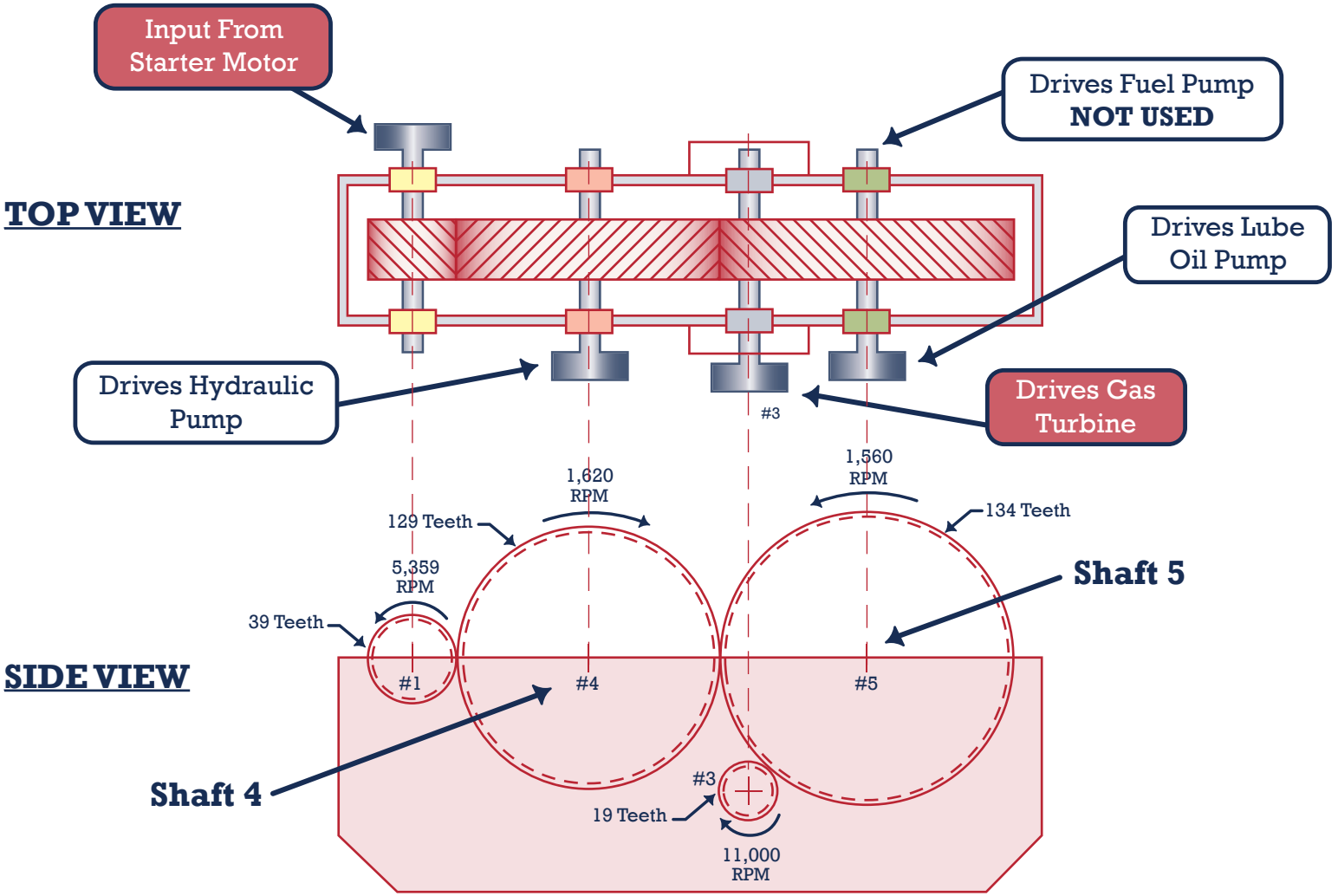


Map from ConocoPhillips website

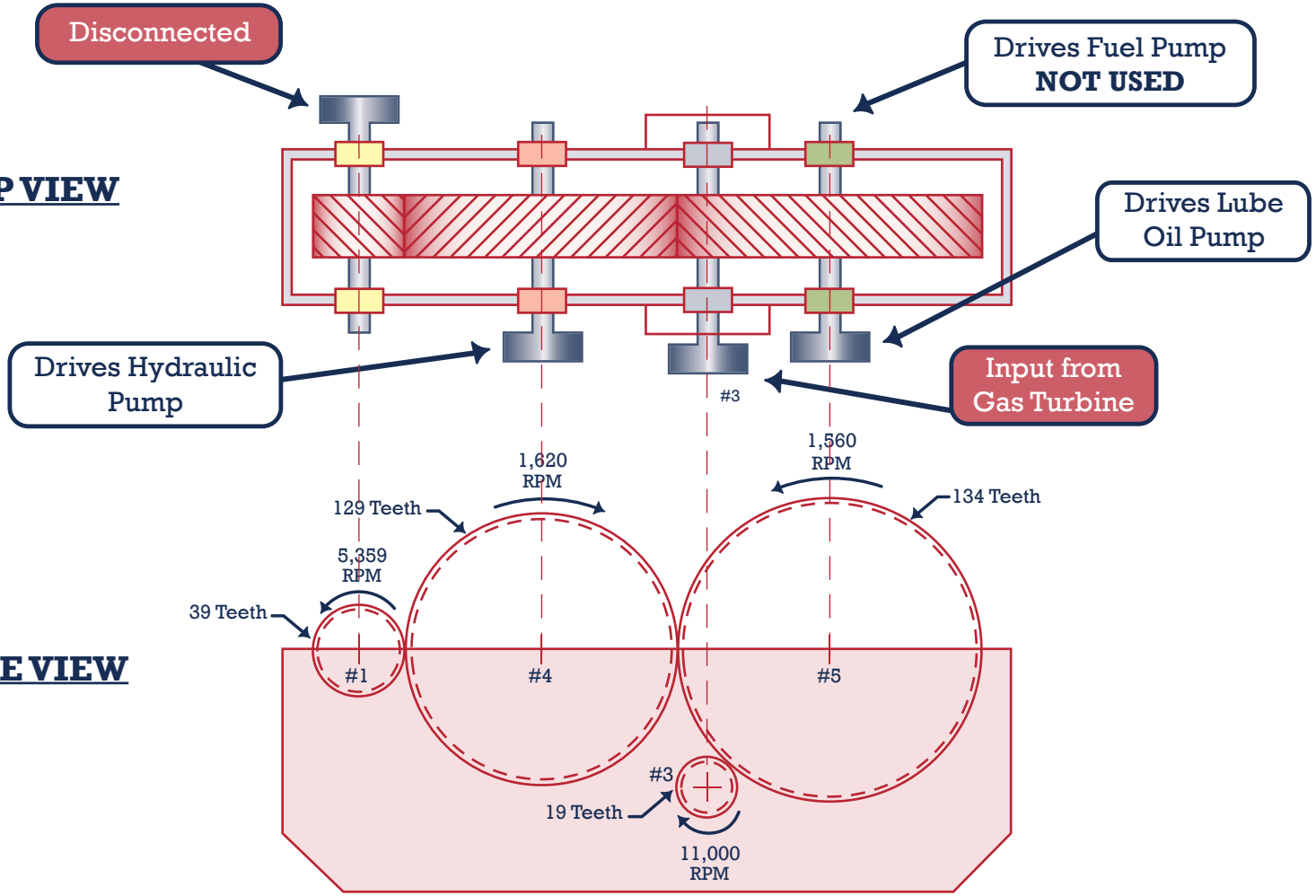
Gearbox

- Motor drives gearbox to start the gas turbine
- Also driven off the gearbox:
  - Hydraulic pump
  - Oil pump
  - Fuel pump – not used
- Once started the motor disengages and the turbine drives the pumps
- Changing from driving to driven changes bearing load directions

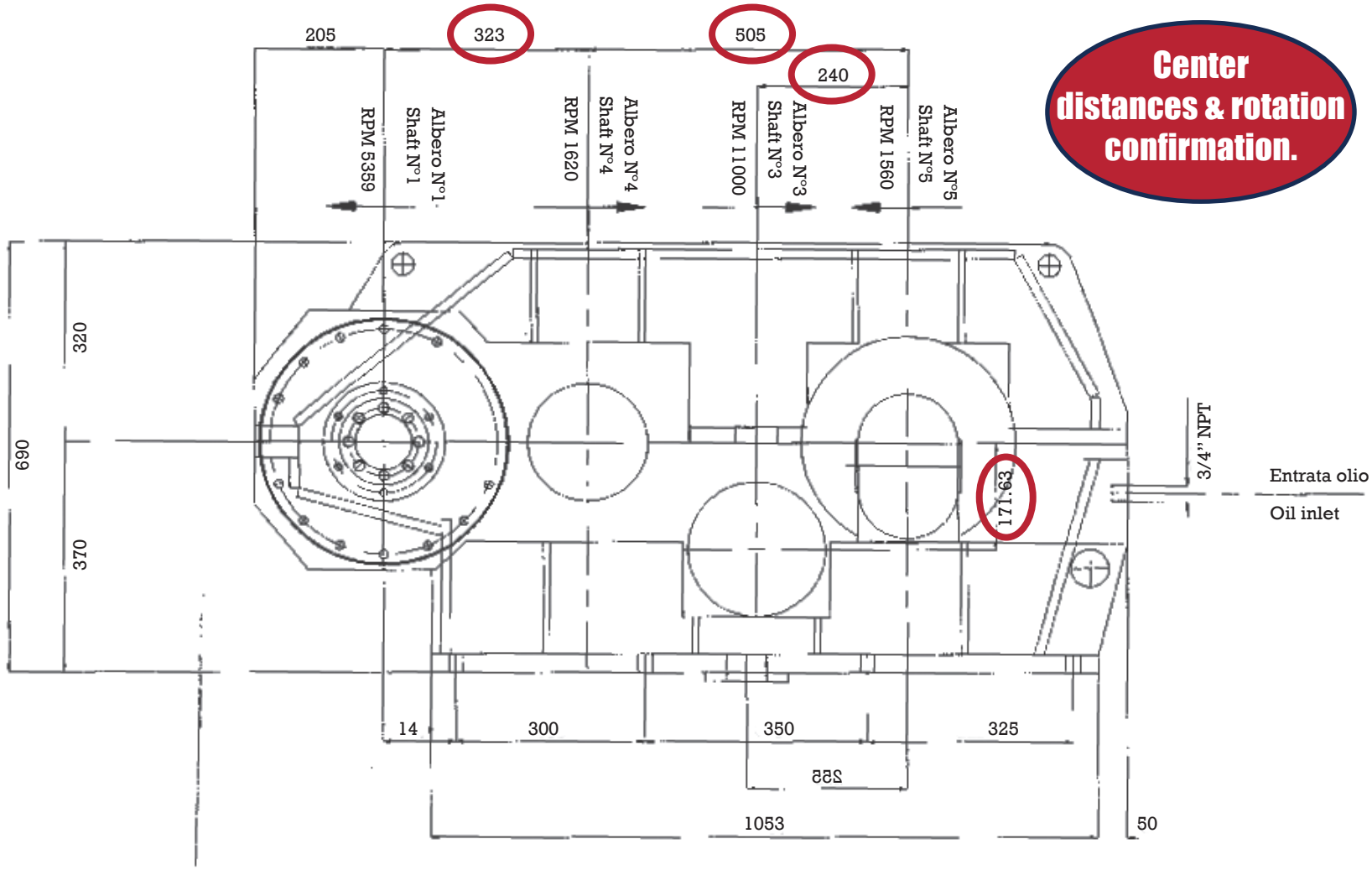
Gearbox


Input From Starter Motor
Drives Fuel Pump NOT USED
TOP VIEW
Drives Lube Oil Pump
Drives Hydraulic Pump
Drives Gas Turbine
#3
1,560 RPM
1,620 RPM
129 Teeth
134 Teeth
5,359 RPM
Shaft 5
39 Teeth
SIDE VIEW
#1
#4
#5
Shaft 4
#3
19 Teeth
11,000 RPM

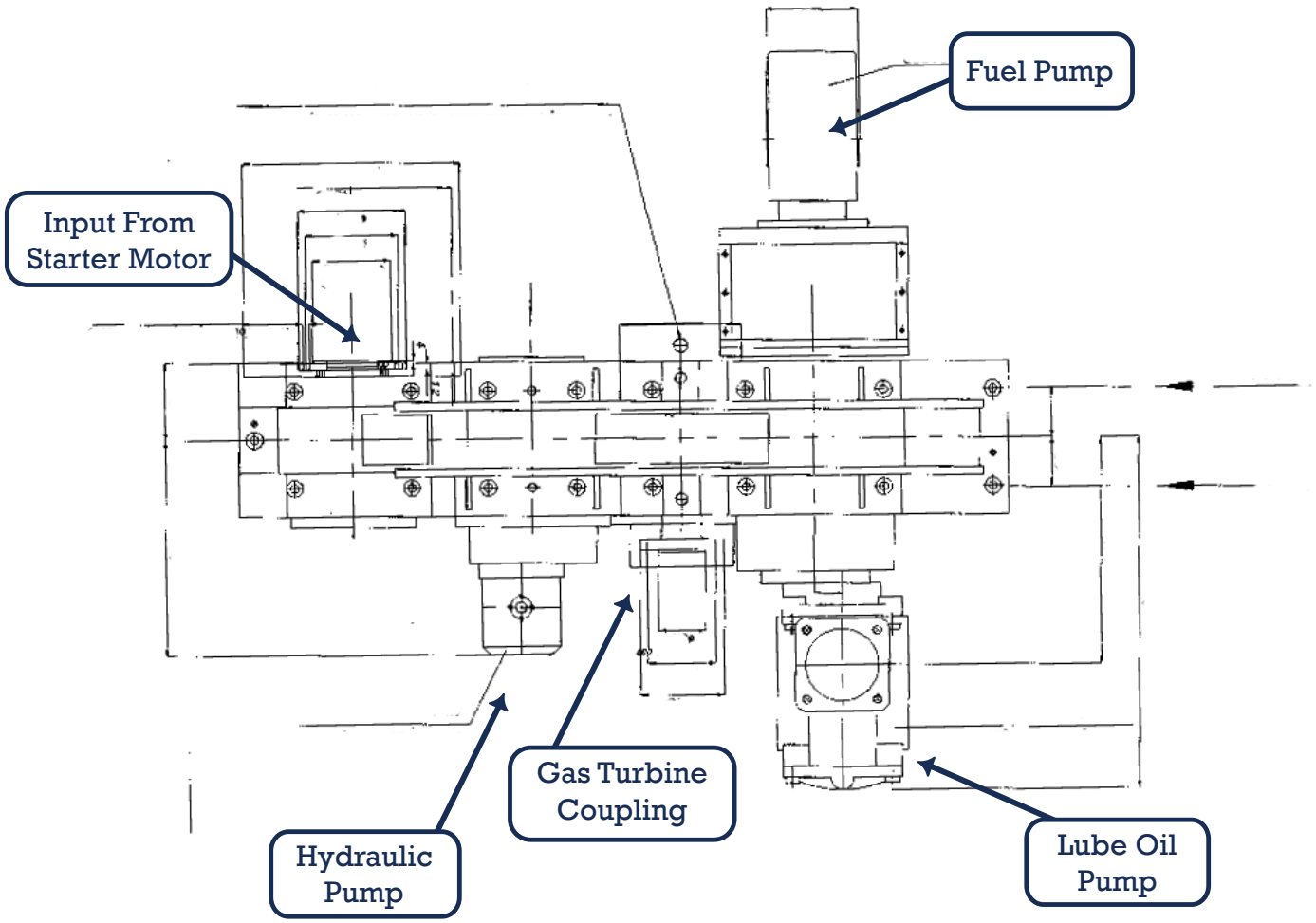
Gearbox


Disconnected
Drives Fuel Pump
NOT USED
TOP VIEW
Drives Lube
Oil Pump
Drives Hydraulic
Pump
Input from
Gas Turbine
#3
1,560
RPM
1,620
RPM
129 Teeth
134 Teeth
5,359
RPM
39 Teeth
SIDE VIEW
#1
#4
#5
#3
19 Teeth
11,000
RPM

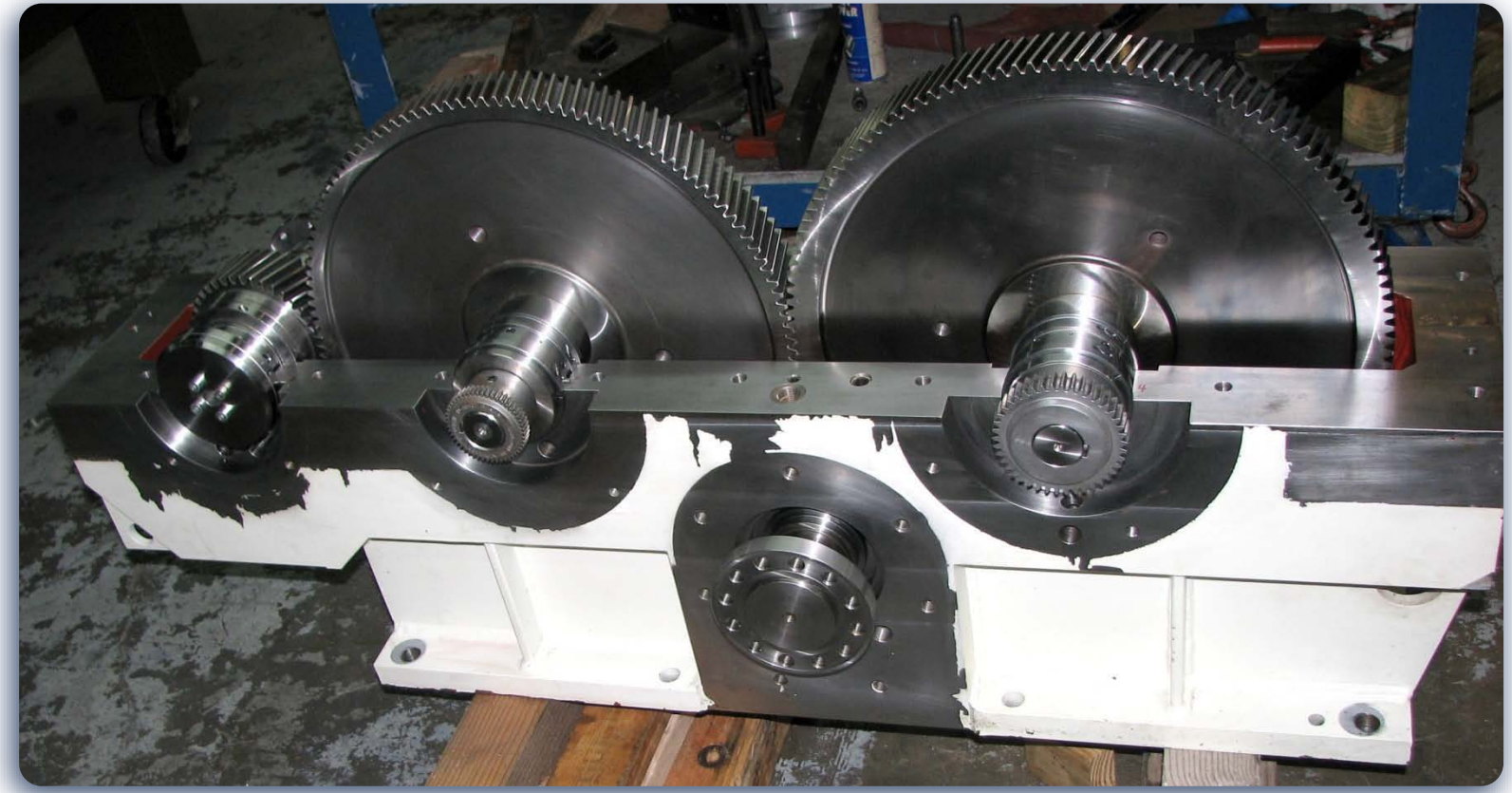
Gearbox


Center distances & rotation confirmation.
205
323
505
240
RPM 5359
Albero N°1
Shaft N°1
RPM 1620
Albero N°4
Shaft N°4
RPM 11000
Albero N°3
Shaft N°3
RPM 1560
Albero N°5
Shaft N°5
320
690
370
171.63
3/4'' NPT
Entrata olio
Oil inlet
14
300
350
325
255
1053
50

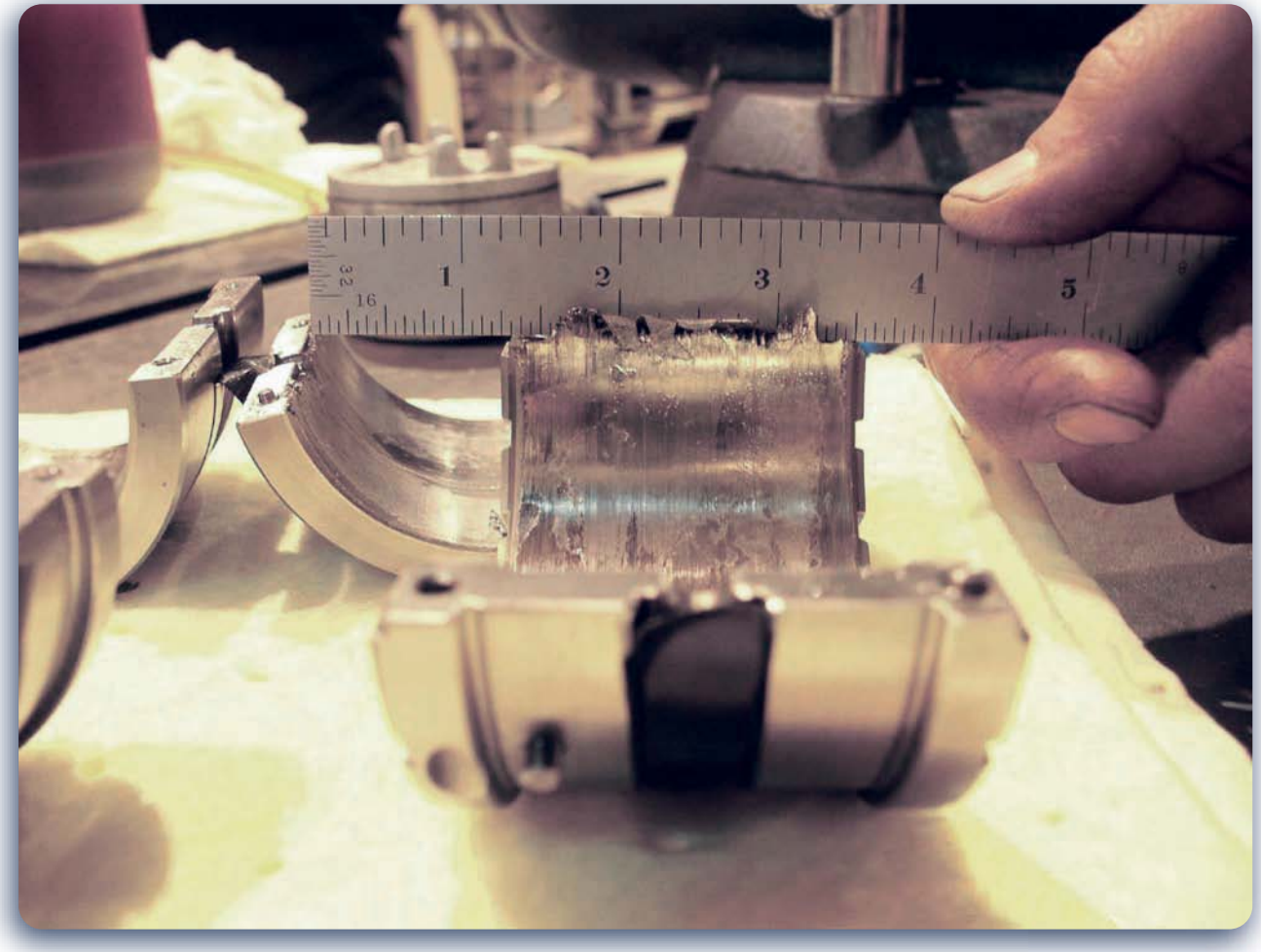
Gearbox


Fuel Pump
Input From Starter Motor
Gas Turbine Coupling
Hydraulic Pump
Lube Oil Pump

Gearbox-Turbine Side



Failed Bearings



Failed Bearings

#4 Journal Bearing- As installed

Failed Bearings

#4 Journal Bearing- Looking at Upper Half

Failed Bearings

#4 Thrust Bearing- As Installed

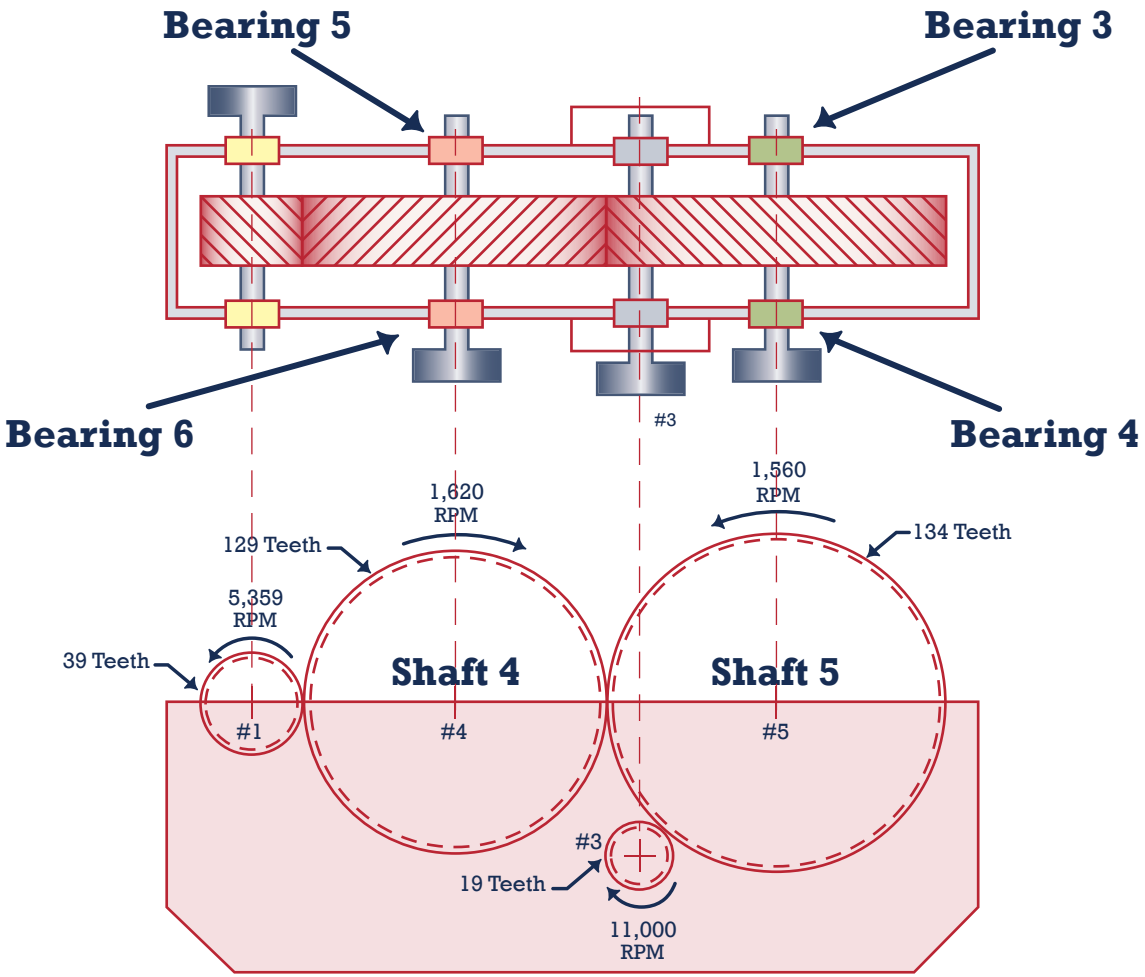
Failed Bearings

#4 Thrust Bearing- Looking at Upper Half

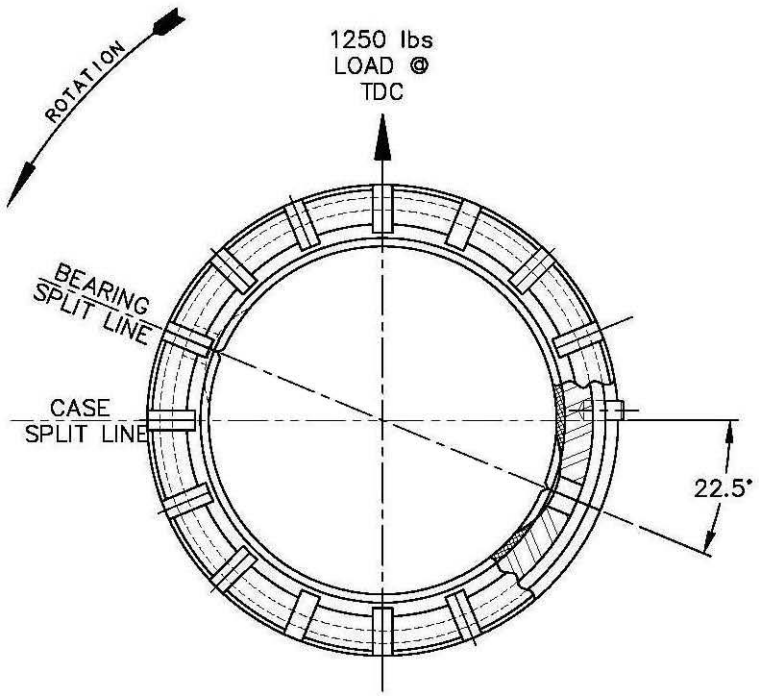
Load Analysis

- Had center distances, speeds, and ratios
- Estimated pressure and helix angles
- Estimated hp
  - For pumps used aux motor sizes
  - Used motor HP for startup
- Two scenarios
  - Start up – driven by motor
  - Running – driven by turbine

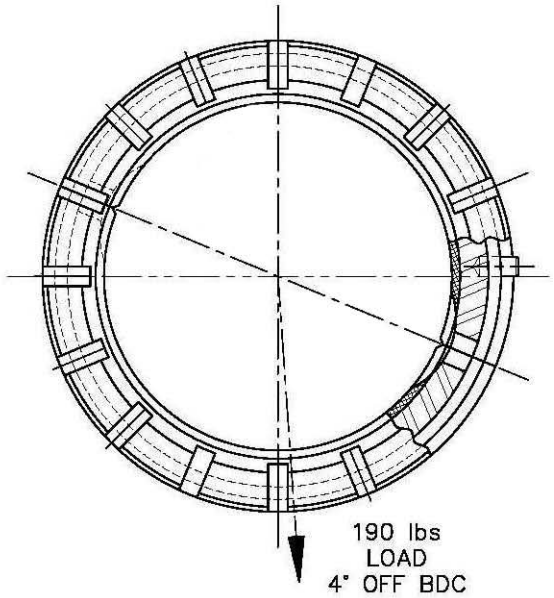
Bearing Numbering



Load Analysis – Bearing 6

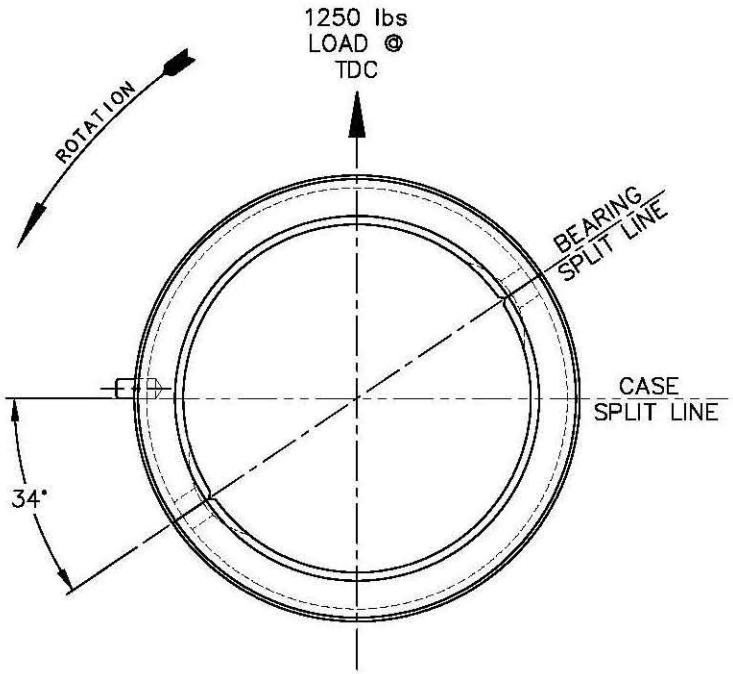


LOAD AT START–UP

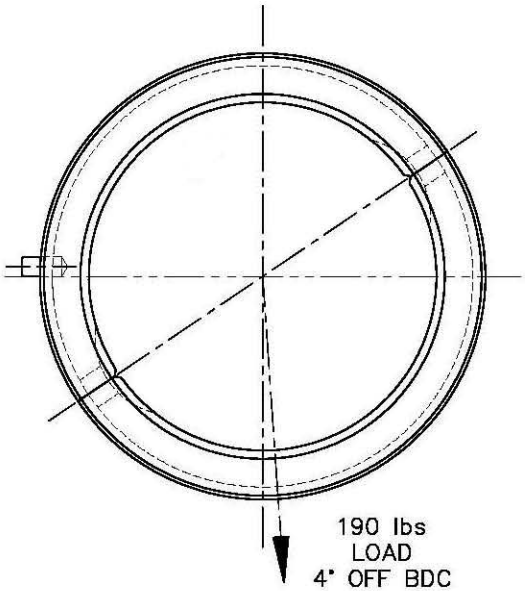


RUNNING LOAD

Load Analysis – Bearing 5

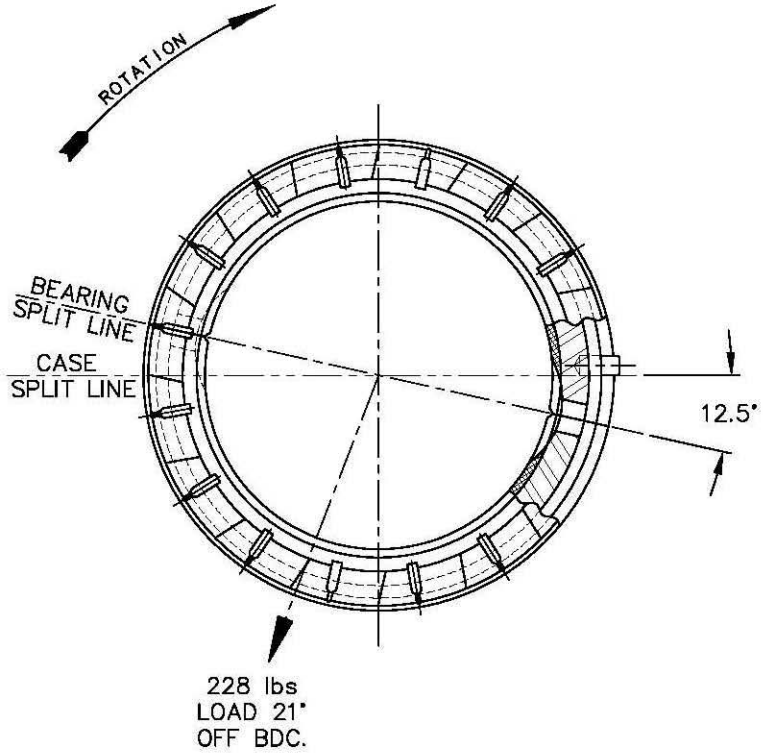


LOAD AT START–UP

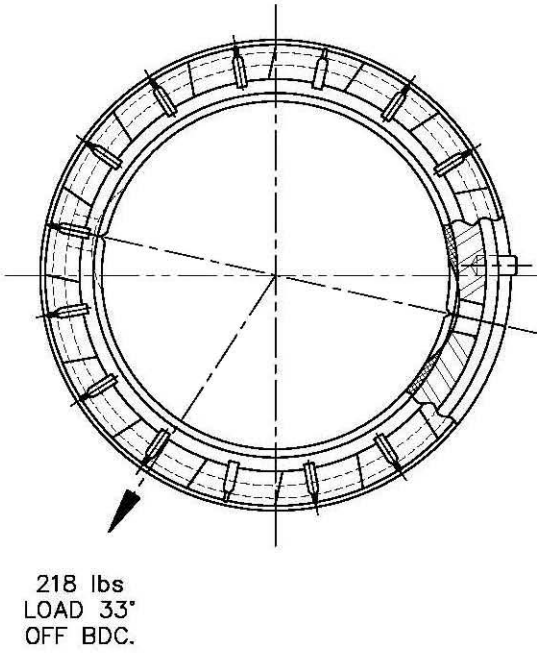


RUNNING LOAD

Load Analysis – Bearing 3



LOAD AT START–UP

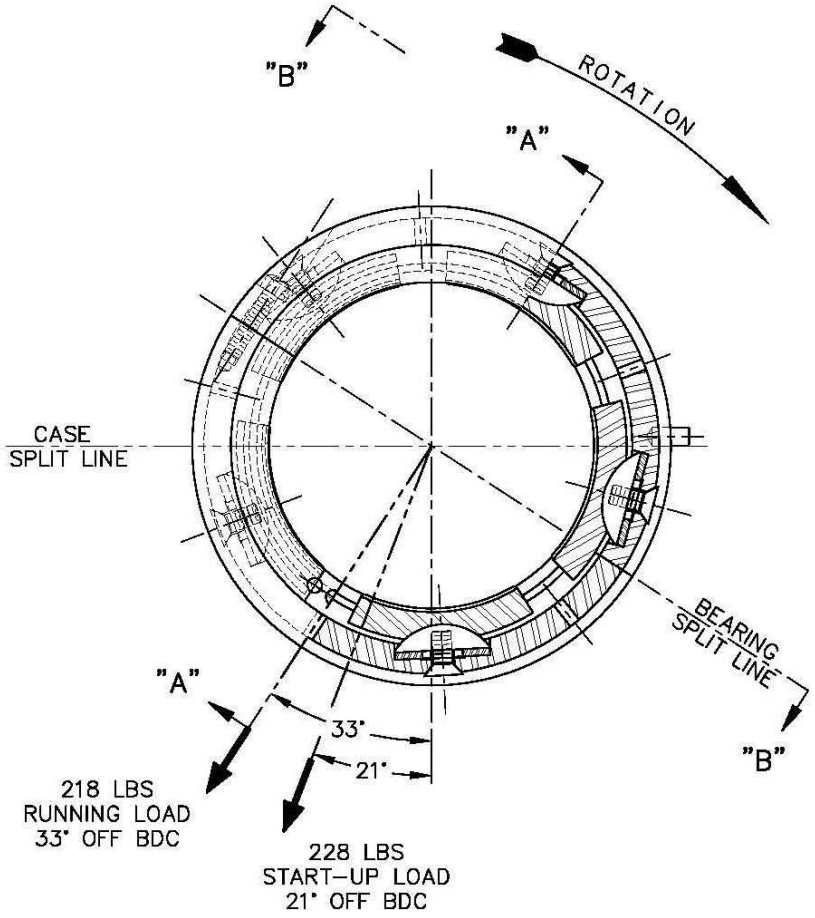


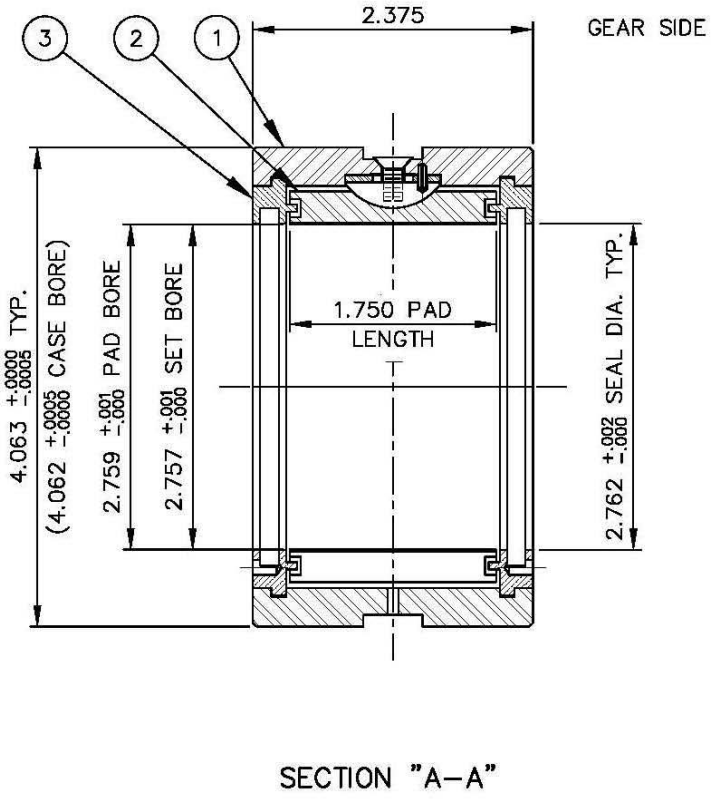
RUNNING LOAD

Failed Bearings

- Bearings from shaft 4 and 5 failed
- Shaft 4 experiences severe load angle changes
- Shaft 5 not as severe
- Decided to upgrade to Tilting Pad Journal Bearings
  - Reduce sensitivity to load angles
- Installed and running successfully

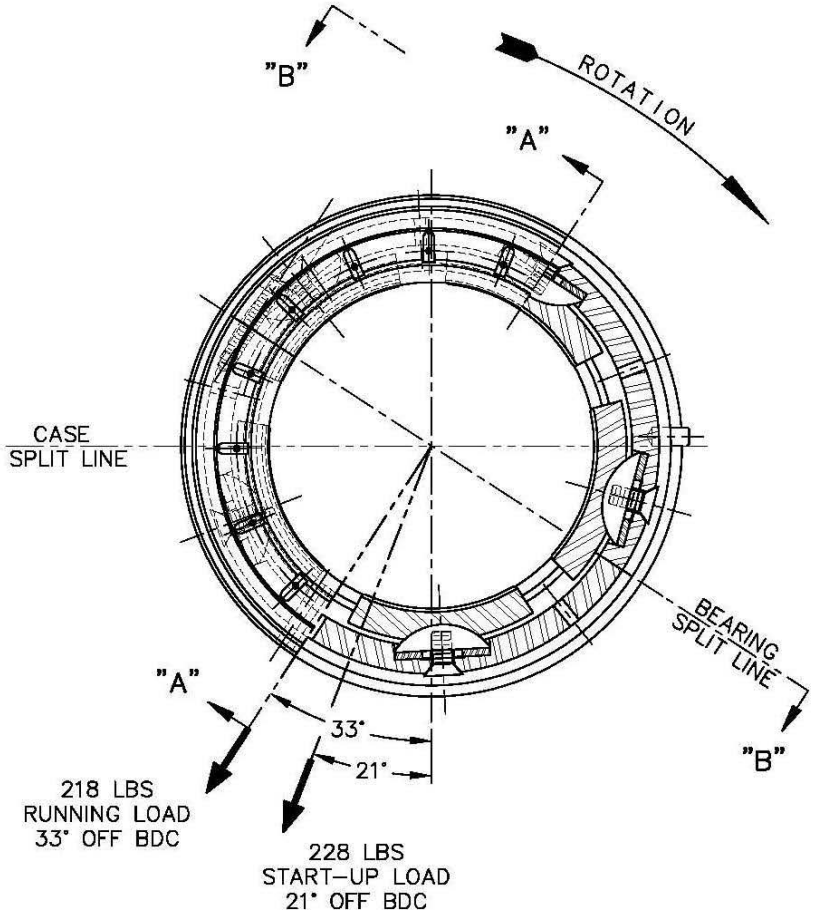
Tilting Pad Journal Bearings – Bearing 3

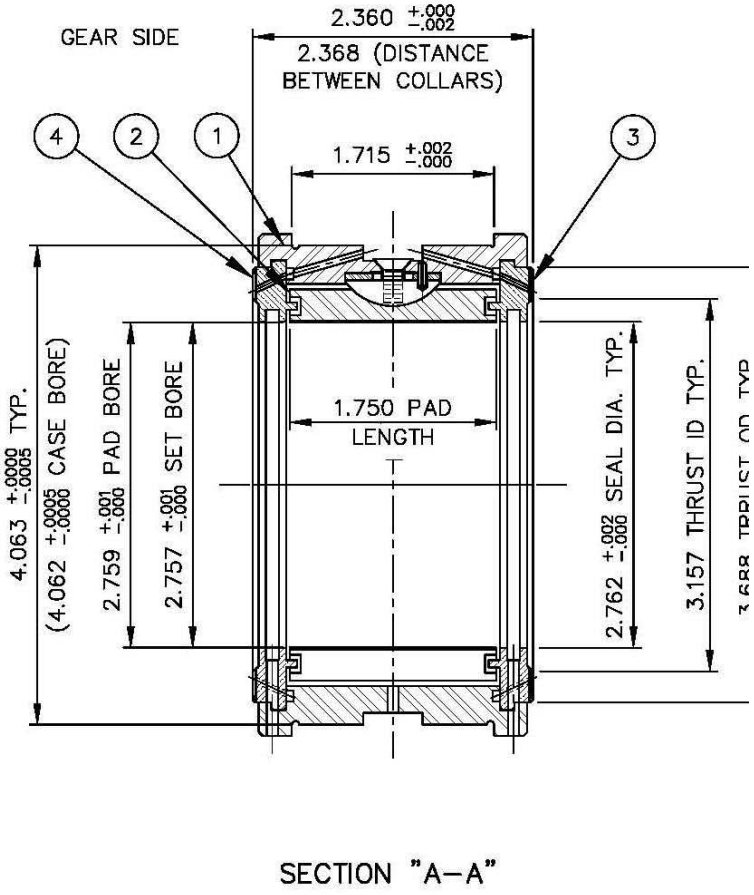




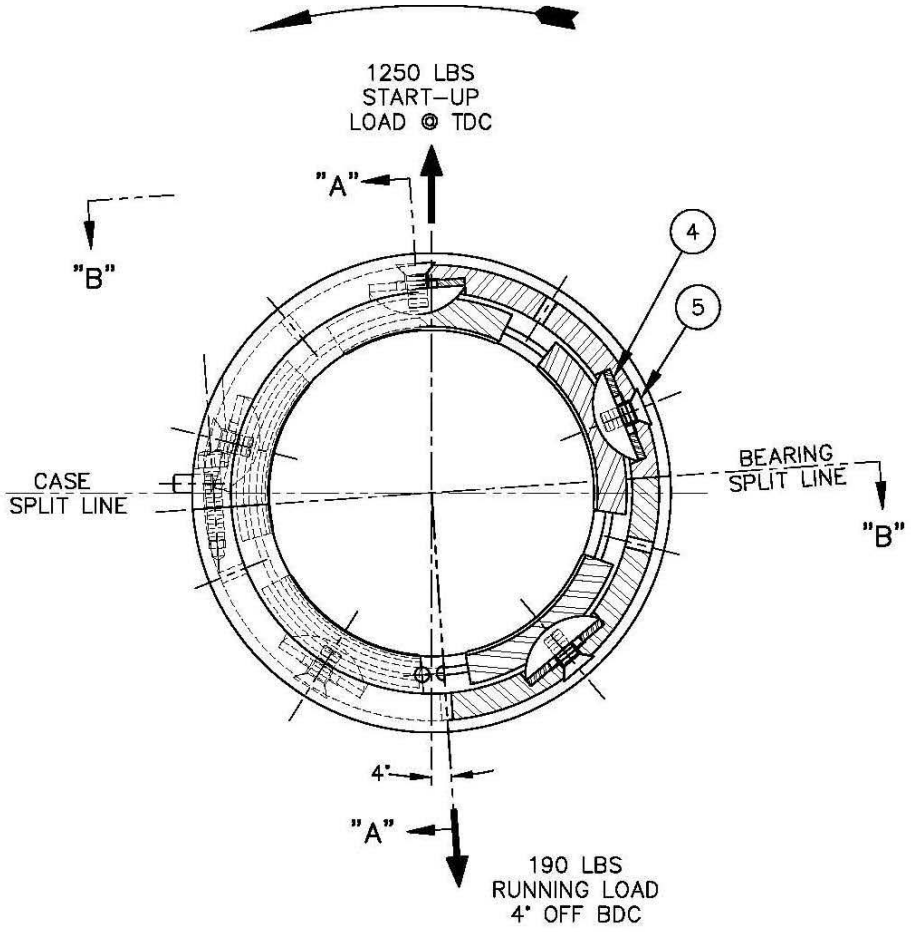
SECTION "A–A"

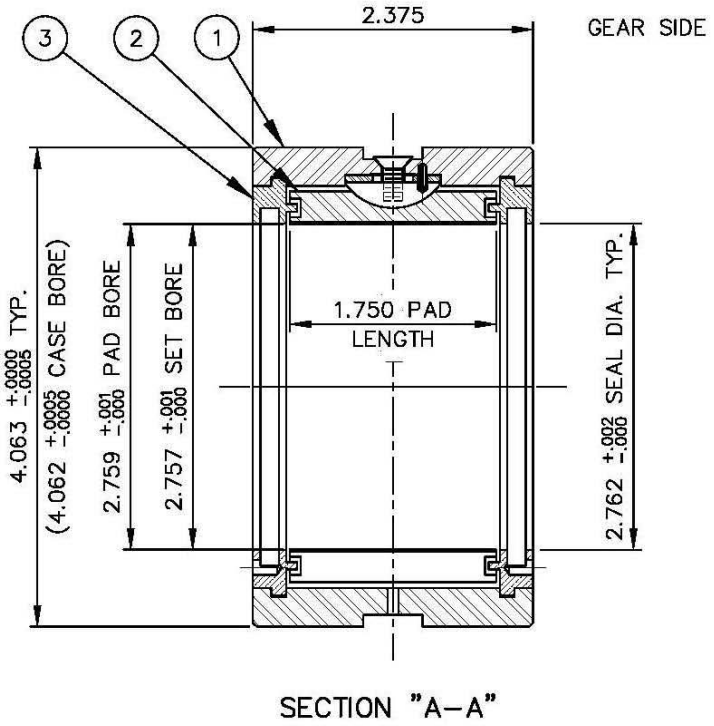
Tilting Pad Journal Bearings – Bearing 4



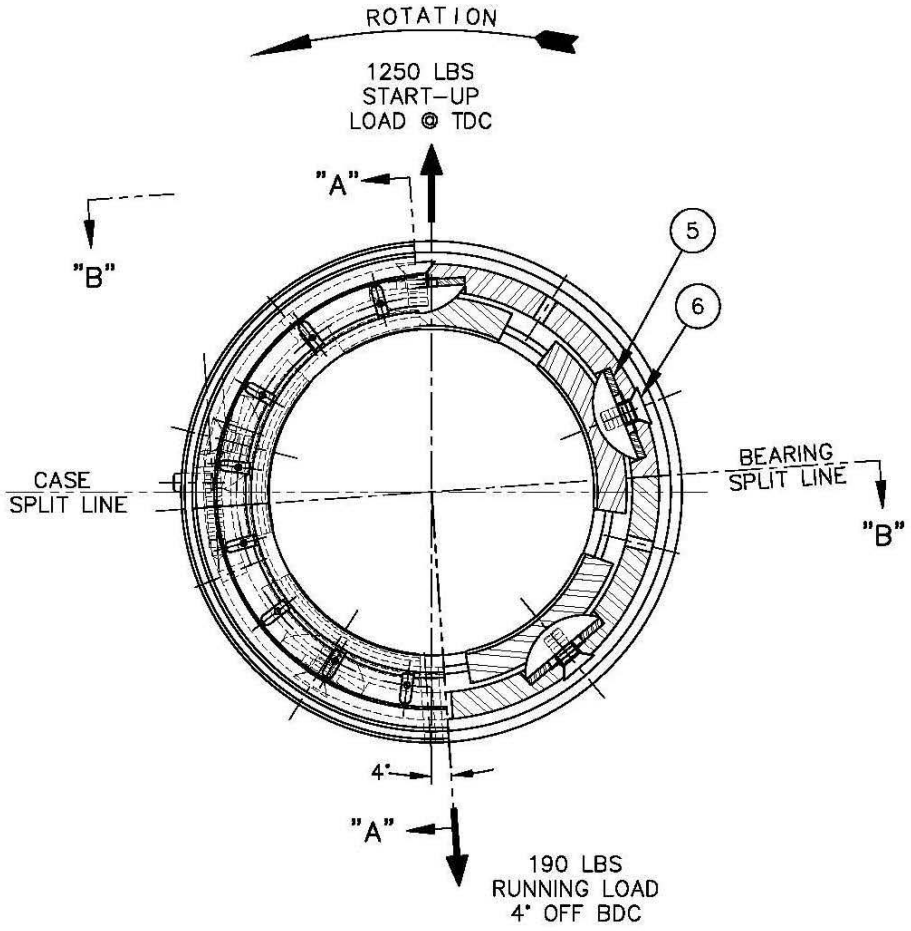


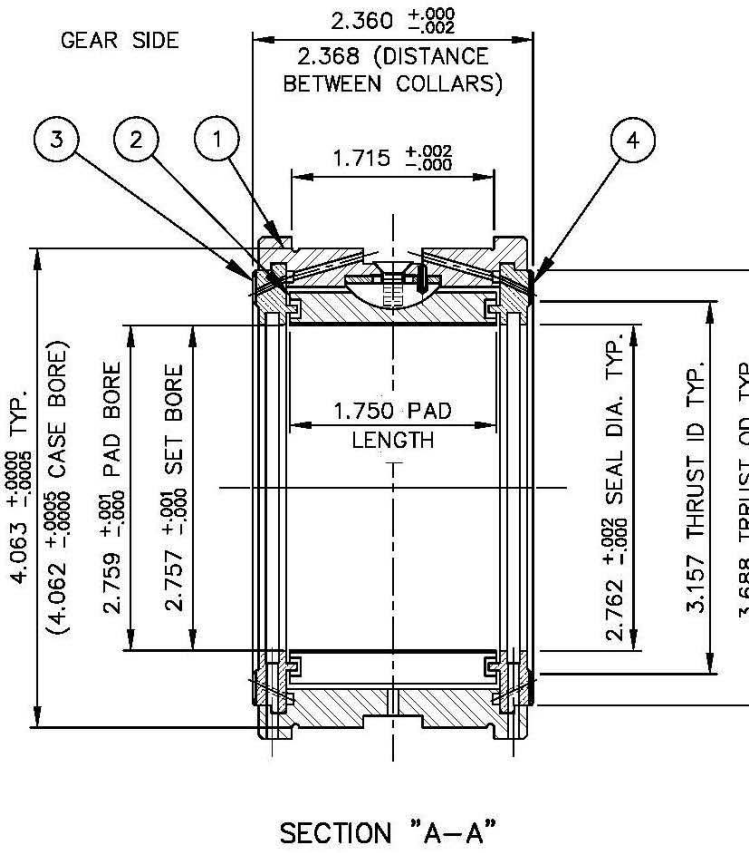
Tilting Pad Journal Bearings – Bearing 5





Tilting Pad Journal Bearings – Bearing 6





CONCLUSIONS

- Changing from a driver to a driven caused bearing load angle changes
- Tilting Pad journal bearings are not as sensitive to these load angle changes
- Bored out the case to accept the larger TPJ's
- Installed and running successfully for a few years now – several starts
- ConocoPhillips has plans to upgrade spare box